CLAIMS

We claim:

1. An apparatus for measuring a parameter of interest of a material comprising:

(a) a cylindrical enclosure for enclosing the material;

(b) at least one transmitter having an antenna on the inside of the cylindrical enclosure for propagating electromagnetic radiation in the material at at least two frequencies; and

(c) at least one receiver having an antenna on the inside of the cylindrical enclosure for measuring electromagnetic radiation in the material at each of the at least two frequencies, the measurements indicative of the parameter of interest.

2. The apparatus of claim 1 further comprising a processor for processing data measured by the receivers wherein the processed data comprises measures of the parameters of interest.

3. The apparatus of claim 1 wherein the parameter of interest is selected from the group consisting of (i) resistivity and (ii) dielectric constant of the material.

4. The apparatus of claim 1 wherein the material is at least one of a (i) liquid, (ii) solid, and, (iii) a gas.

5. The apparatus of claim 4 wherein the material is flowing.

6. The apparatus of claim 4 wherein the material is stationary.

7. The apparatus of claim 1 wherein the at least one transmitter comprises at least two transmitters, the at least one receiver comprises at least two receivers, and wherein the at least two transmitters are symmetrically arranged about the at least two receivers.

8. The apparatus of claim 1 wherein the material is in a subterranean formation, the apparatus further comprising:
(i) a core bit operatively coupled to the cylindrical enclosure for separating the material from the subterranean formation, and, (ii) a drilling tubular for conveying the cylindrical enclosure into a borehole in the subterranean formation wherein the drilling tubular is selected from the group consisting of (A) a drill string and (B) a coiled tubing.

9. The apparatus of claim 1 wherein the at least one transmitter antenna is set in a circumferential recess on the inside of the cylindrical enclosure.

10. The apparatus of claim 9 further comprising a ferrite material positioned in the recess for shielding the cylindrical enclosure from electromagnetic radiation.

11. The apparatus of claim 9 further comprising an epoxy potting material for fixing

the at least one transmitter antenna in the recess and protecting the antenna from damage.

12. The apparatus of claim 1 wherein each said antenna is set in a plurality of apertures on the inside of the cylindrical enclosure.

13. The apparatus of claim 12 further comprising a ferrite material positioned in the apertures for electromagnetic shielding of the cylindrical enclosure.

14. The apparatus of claim 12 further comprising an epoxy potting material for fixing the antenna in the apertures and protecting the antenna from damage.

15. A method for determining a parameter of interest of a material comprising:

(a) enclosing the material in a cylindrical enclosure;

(b) inducing electromagnetic radiation in the material using at least one transmitter antenna on the inside of the cylindrical enclosure transmitting at least two frequencies; and

(c) measuring with at least one receiver antenna the induced electromagnetic radiation in the material at each of the frequencies, the measurements indicative of the parameter of interest.

16. The method of claim 15 further comprising using a processor for processing the data to determine measures of the parameters of interest.

17. The method of claim 16 wherein the processor is at a location selected from the group consisting of (i) down hole on a drill string and (ii) on the surface for real time monitoring.

18. The method of claim 15 wherein the parameter of interest is selected from the group consisting of (i) resistivity and (ii) dielectric constant of the material.

19. The method of claim 15 wherein the material is selected from the group consisting of (i) a liquid, (ii) a solid, and (iii) a gas.

20. The method of claim 19 wherein the material is flowing.

21. The method of claim 19 wherein the material is stationary.

22. The method of claim 15 wherein the at least one transmitter comprises at least two transmitters, the at least one receiver comprises at least two receivers, and wherein the at least two transmitters are symmetrically arranged about the at least two receivers.

23. The method of claim 15 further comprising:

(i) operatively coupling a core bit to the enclosure;

(ii) conveying the enclosure into a borehole in a subterranean formation on a

drilling tubular; and

(iii) operating the core bit for separating the material from the subterranean formation;

wherein the drilling tubular is selected from the group consisting of (A) a drill string and (B) a coiled tubing.

24. The method of claim 15 wherein the location of the at least one transmitter antenna and the at least one receiver antenna is selected from the group consisting of (i) a recess in the enclosure and (ii) a plurality of apertures in the enclosure.

25. The method of claim 24 further comprising shielding the cylindrical enclosure from electromagnetic radiation with a ferrite material.

26. The method of claim 24 further comprising fixing the at least one transmitter antenna and the at least one receiver antenna in place with an epoxy potting material.

27. An apparatus for measuring a parameter of interest of a material comprising:

(a) a cylindrical enclosure for enclosing the material;

(b) at least two transmitters each having an antenna on the inside of the cylindrical enclosure for propagating electromagnetic radiation in the material at least one frequency;

(c) at least two receivers each having an antenna on the inside of the

cylindrical enclosure for measuring electromagnetic radiation in the material at the at least one frequency, the measurements indicative of the parameter of interest.

wherein the at least two transmitters are symmetrically arranged about the at least two receivers.

28. The apparatus of claim 27 further comprising a processor for processing data measured by the receivers wherein the processed data comprises measures of the parameters of interest.

29. The apparatus of claim 27 wherein the parameter of interest is selected from the group consisting of (i) resistivity and (ii) dielectric constant of the material

30. The apparatus of claim 27 wherein the material is in a subterranean formation, the apparatus further comprising:

(i) a core bit operatively coupled to the cylindrical enclosure for separating the material from the subterranean formation, and,

(ii) a drilling tubular for conveying the cylindrical enclosure into a borehole in the subterranean formation.

31. The apparatus of claim 30 wherein the drilling tubular is selected from the group consisting of (A) a drill string, and, (B) a coiled tubing.

32. The apparatus of claim 27 wherein each transmitter antenna is set in a circumferential recess on the inside of the cylindrical enclosure.

33. The apparatus of claim 32 further comprising a ferrite material positioned in the recess for shielding the cylindrical enclosure from electromagnetic radiation.

34. The apparatus of claim 27 wherein the at least one frequency further comprises at least two frequencies.

35. A method for determining a parameter of interest of a material comprising:

(a) enclosing the material in a cylindrical enclosure;

(b) arranging a first transmitter antenna and a second transmitter antenna symmetrically about a first receiver antenna and a second receiver antenna;

(c) inducing electromagnetic radiation in the material by sequentially activating the first and second transmitter antennas at at least one frequency; and

(d) measuring with the first and second receiver antennas the electromagnetic radiation induced in the material by the first and second transmitter antennas, said measurements indicative of the parameter of interest.

36. The method of claim 35 further comprising using a processor for processing the data to determine measures of the parameters of interest.

37. The method of claim 36 the processor location is selected from the group consisting of (i) down hole on a drill string and (ii) on the surface for real time monitoring.

38. The method of claim 35 further comprising:

(i) operatively coupling a core bit to the enclosure;

(ii) conveying the enclosure into a borehole in a subterranean formation on a drilling tubular; and

(iii) operating the core bit for separating the material from the subterranean formation.

39. The method of claim 38 wherein the drilling tubular is selected from the group consisting of (A) a drill string and (B) a coiled tubing.

40. The method of claim 35 wherein the location of the transmitter antennas and the receiver antennas is selected from the group consisting of (i) a recess in the enclosure and (ii) a plurality of apertures in the enclosure.

41. The method of claim 35 wherein the at least one frequency further comprises at least two frequencies.